Nov. 20, 1945. H. J. TYZZER 2,389,472

ELECTRICAL ENERGY CONVERSION

Filed April 7, 1942

FIG. 2

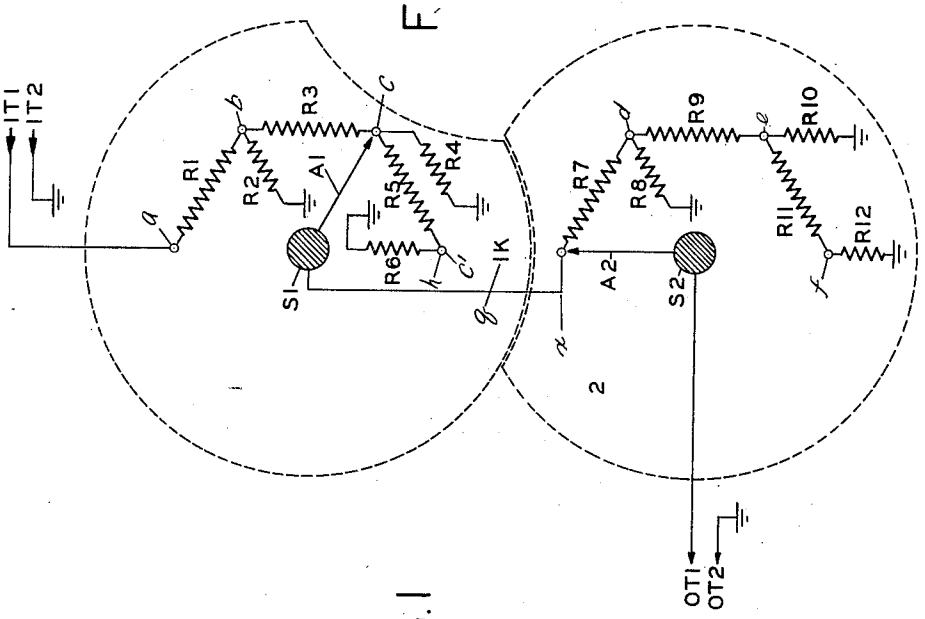
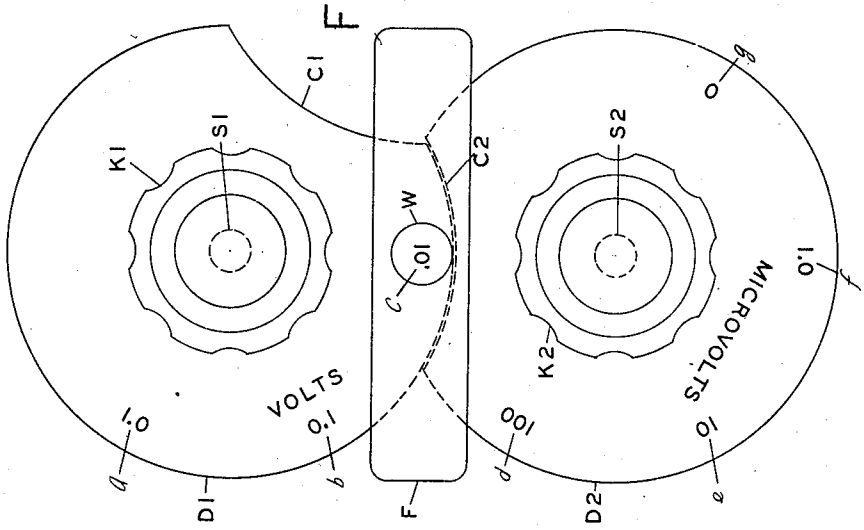


FIG. 1



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2,389,472

ELECTRICAL ENERGY CONVERSION

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Application April 7, 1942, Serial No. 437,976

6 Claims. (Cl. 178—44)

My present invention broadly relates to the conversion of an electrical potential of a given order into one or more potentials of lower order, and more particularly relates to the conversion of given potentials developed by high frequency electrical alternating currents into lower order high frequency alternating potentials.

A particular object of my present invention is the provision of means making possible the conversion of given electrical potentials into useable predetermined minute fractions thereof without materially interfering with the accuracies of the particular varieties of conversion, and the means I use, in its broad aspects, may be properly included in the category of potentiometers as known to the art.

A particular application for the means of my present invention is in connection with so-called resistance attenuators, such as those shown and described in Ferris U. S. Patent No. 2,131,101, which have become extensively used as a part of so-called Standard Signal Generators, which device is fully shown and described in Ferris U. S. Patent No. 2,265,637 of December 9, 1941.

Under some conditions that have developed since the 1937 filing dates of the said Ferris patents, the attenuators of more recently developed standard signal generators are called upon to reduce the high and very high radio frequency alternating potentials from the values of the order of one or two volts down to less than one millionth of a volt, more commonly spoken of as one microvolt. At the high radio frequencies involved, this reduction to the order of one millionth is fraught with highly perplexing difficulties due to hard to eliminate stray couplings between the elements carrying high frequency energy of one to two volts of potential and the elements intended to carry minute fractions of the energies involved; which conditions come into play to objectionable extents even when the usual attenuator unit is built of substantially a solid mass of metal, with the only exceptions being such holes and slots therein as are required for necessary contacts and network resistors.

From the foregoing, it is fundamentally obvious that the more the reductions in potentials called for are increased, the more effective do the before mentioned stray couplings between the high and the low potential elements become in any one attenuator unit, with the inaccuracies of the output potentials increased accordingly. Thus, I have found by actual practice that even though very careful attenuator design is brought to bear with which reductions of potentials to the order of one hundred thousandths are obtainable with reasonable accuracies, further reductions therebeyond are accompanied with correspondingly increased and highly objectionable inaccuracies.

I have found that by in effect cascading two or more suitably designed attenuator units, the above mentioned stray coupling effects are so effectively minimized that reductions well beyond one hundred thousandths of the initial potentials involved can be carried out with effectively higher orders of accuracies over anything possible with a single attenuator unit.

Without special means to avoid the conditions, the use of two or more attenuator units, each having a multiplicity of predetermined in value steps, in cascaded relation would introduce highly perplexing complications due to the fact that the operator would be forced to engage in calculations for each and every adjustment of each of the attenuator steps to arrive at the total reduction of the input potential brought about; and it is another object of my present invention to provide visible showings of the actual values to which the original potential or potentials is or are reduced, and thereby completely eliminate the labor and loss of time that would flow out of the necessary calculations in the absence of such means.

To aid in more thoroughly describing the essential elements and their respective functions in the case of the means needed for practicing my present invention, I use the two figures of the accompanying drawing, which I first briefly identify as follows:

By Fig. 1, I illustrate certain control elements so designed as to be suitable for mounting on a front panel of a container in which the necessary attenuator units are internally mounted.

By Fig. 2, I illustrate two attenuator units and the necessary operation connections therefor.

Referring to Fig. 1, D1 and D2 illustrate two circular dials, preferably of the same diameter, each having the illustrated cut away portions C1 and C2, respectively, each cut away portion preferably having the same curvature as has the circumference of its dial, the dials being so mounted on indicated rotatable shafts S1 and S2, respectively, and said shafts also being so mounted, that any part of the uncut away circumference of either dial can extend into the cut away portion of the other dial without making frictional contact therewith by being properly rotated by hand knobs K1 and K2, respectively, by the operator using the same. From the shown physical relations of the two dials with respect to each

other, it is obvious that so long as the uncut away portion of dial D1 extends into the cut away portion of dial D2, the latter cannot be rotated, and thus the latter is automatically caused to remain locked in a fixed position; and that the same would be true if these relations of the said dials are reversed.

Dial D1 is shown marked with "Volts," which marking indicates that readings coming from it deal with volt values, and the marking of dial D2 with "Microvolts" indicates that readings coming from it deal with potential values so low that they are better expressed in terms of microvolts.

As shown by Fig. 1, in the position where one of the dials projects into the cut away portion of the other dial, this position, with the exception of that part seen through the window W, is hidden from the view of the operator by a screen F of opaque material mounted outside of the plane of the dials, preferably black or made black to enhance the definition of the circumference of the window W, through which the operator makes his readings, which readings are the figures placed close to the edges of the respective dials at the places marked *a, b, c, d, e, f* and *g*, respectively.

Referring to Fig. 2, the elements S1 and S2 indicate cross sections of the S1 and S2 indicated shafts of Fig. 1 on which dials D1 and D2 of Fig. 1 are so mounted that hand rotations thereof by the operator by the use of knobs K1 and K2 are transmitted in kind to the arms A1 and A2 indicated as attached to shafts S1 and S2, respectively.

To perspectively aid in describing the relations of the elements of Fig. 2 to dials D1 and D2, respectively, the respective areas of the said dials are repeated in Fig. 2 in the shown broken lines, the areas of which are marked 1 and 2, respectively. All of the elements shown in area 1 are controlled in their operation by the rotation of dial D1, and all of the elements shown in the area 2 are controlled in their operation by the rotation of dial D2. By rotating dial D1, the rotating arm A1 may be caused to make temporarily permanent contact with any one of the contact points marked *a, b, c* and *h*, which, with the indicated predetermined resistors go to make up an attenuator unit; and by rotation of dial D2, the rotating arm A2 may be caused to make temporarily permanent contact with any one of the contact points marked *d, e* and *f*, which, with the indicated predetermined resistors, go to make up a second attenuator unit.

As to operation, assuming for example that indicated input terminals IT1 and IT2 are connected across one volt of potential developed by a source of generation of electrical alternating current, such as the usual vacuum tube generator of standard signal generators, and that indicated output terminals OT1 and OT2 are connected across the usual terminated cable of standard signal generators, if arms A1 and A2 are set at their vertical positions, so that A1 contacts contact point *a*, through arm A1, shaft S1, connection *x*, arm A2, shaft S2 there is a direct connection between the input and output terminals by reason of which an unattenuated one volt of potential is delivered to the said output terminals.

If arm A1 is shifted to contact with contact point *b*, due to the predetermined resistance of resistance R1 thus brought into play, attenuation of the one volt of input determined by the value of resistance R1 takes place at the output terminals OT1 and OT2, which, in usual signal generator practice, is designed to be nine tenths of the input potential to leave one tenth (0.1) of a volt for output work. In this case, the 0.1 shown at point *b* on the dial D1 is in view through the window W.

By further shifting arm A1 to contact point *c*, the predetermined values of resistances R2 and R3 brought into play cause further attenuation depending upon their values, usually designed in signal generator work to be sufficient to leave 0.01 of a volt for output work; and in this case, the .01, as shown in Fig. 1, is in view through window W.

By further shifting arm A1 to contact point *c'*, so that the cut away portion C1 of dial D1 extends over the cut away portion C2 of dial D2, the predetermined values of resistances R5 and R6 additionally brought into play cause further, but the last, attenuation of the input potential by attenuator unit 1, to leave for output work only 0.001 of a volt, or 1000 microvolts. In this case, the edge portions of the dials D1 and D2 do not show through window W because of being cut away, but any symbol placed on the panel in line with window W will show through the same; and in my case, I have used the symbol 1K, marked for identification by *g*, as an abbreviation for 1000 to act as a sort of notice to the operator that no further operation can be had through dial D1.

At this point, the dial D2 becomes unlocked, and by shifting arm A2 to contact point *d*, dial D1 becomes locked, and remains so as long as arm A2 is out of a vertical position. In the case of signal generator work, the 100 shown at point *d* by Fig. 1, which comes into view through window W, is evidence to the operator that 100 microvolts are left for output work; on shifting arm A2 to contact point *e*, the 10 shown at point *e* by Fig. 1 is evidence to the operator that 10 microvolts are left for output work; on shifting arm A2 to contact point *f*, the 1.0 shown at point *f* by Fig. 1 is evidence to the operator that that 1.0 microvolt is left for output work; and by shifting arm A2 farther along, the 0 shown at point *g* by Fig. 1 is evidence to the operator that no potential is available for output work.

As in the case of attenuator unit 1, the predetermined values of the resistances R7, R8, R9, R10, R11 and R12, shown as belonging to attenuator unit 2, determine the step-by-step attenuation brought about by attenuator unit 2 after the limit by attenuator unit 1 has been reached. Of course, it is obvious that by proper selections of the resistance values of each of the attenuators, the step-by-step attenuation can be predeterminedly varied to suit the requirements of any particular service.

While I have described my present invention in certain confined respects, it is apparent that modifications may be made, and that no limitations are intended other than those imposed by the scope of the appended claims.

What I claim as new and desire to secure by Letters Patent of the United States is as follows:

1. In an arrangement for converting a fixed in value potential of any one of a large number of high frequency electrical alternating currents into any one of a multiplicity of lower predetermined in values potentials, the combination of input and output terminals for the said electrical alternating currents, a plurality of multiple element resistance attenuator units connected in cascade relation between the said terminals in

sufficiently removed spaced relations with respect to each other that the stray couplings between the resistance elements of any one unit and any other unit are materially less than they would be if contained in the same unit, contacts separating the individual predetermined resistances of the said attentuator units, separate rotatable contact arms in each of the said units each independently arranged for successively contacting the said contacts of its attentuator unit and means dependent upon mechanical action only jointly associated with the said rotatable arms so arranged that the arm of the attenutor unit nearer the said input terminals must be in one chosen position to make the arm of the next attentuator unit rotatable.

2. The arrangement of claim 1 in which the rotatable contact arm of a preceeding attenuator unit must be in contact with the last one of its input contacts to make the arm of the next attenuator unit rotatable.

3. The arrangement of claim 1 in which the individual rotatable contact arms of the respective attenuator units cannot be simultaneously rotated to any effective extent.

4. In an arrangement for converting a fixed in value potential of any one of a large number of high frequency electrical alternating currents into any one of a multiplicity of lower predetermined in values potentials, the combination of input and output terminals for the said electrical alternating currents, a pair of multiple element resistance attenuator units in cascade relation connectable between the said terminals in sufficiently removed spaced relation to each other that the stray couplings between the elements of the said attenuator units are materially less than they would be if contained in the same unit, contacts separating the individual predetermined resistances of the said attentuator units, a separate rotatable contact arm in each of the said units arranged for successively contacting the said contacts of its attenuator unit and mechanical means so jointly controlling the said contact arms that only upon completion of the maximum possible attenuation of the said fixed in value potentials by the first attenuator unit is the further attenuation of the resulting attenuated potentials performable by the second attenuator unit to the extents provided for.

5. In an arrangement for converting a fixed in value potential of any one of a large number of high frequency electrical alternating currents into any one of a multiplicity of lower predetermined in values potentials, the combination of two substantially circular dials each having substantially like cut-away edges, the said dials being so rotatably and overlappingly mounted in the same plane that neither can be effectively rotated except when the other is in substantially one definite position, shafts forming mounting means for the said dials each having affixedly attached thereto a contact arm located so as to rotate with its corresponding dial in a plane substantially parallel to the plane of the same, two sets of a plurality of spaced contacts, the contacts of each set being so distributed as to individually make contact with its corresponding contact arm at predetermined positions thereof, predetermined in values resistors connected between pairs of the said contacts in series relation to each other in the case of each set of contacts to form separate attenuator units in sufficiently removed spaced relation to each other that the stray couplings between the respective elements thereof are materially less than they would be if contained in the same unit, an electrical alternating current input connection to the first contact of one attenuator unit, an electrically conductive connection between the contact arm of the said attenuator unit and the first contact of the second attenuator unit and an electrical alternating current output connection to the contacting arm of the second attenuator unit.

6. The arrangement of claim 5 in which an effectively opaque screen having a centralized window therethrough otherwise occults the overlapping region of the dials and in which the dials have properly distributed potential value markings so located thereon as to separately fall in line with said window as varieties of operations are carried out with different values of potential within the overall potential range of the arrangement.

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